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GLOBAL AGRICULTURAL VALUE CHAINS AND STRUCTURAL TRANSFORMATION

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ABSTRACT

Since the mid-1900s, agricultural global value chains (AGVCs) have grown rapidly and transformed the nature of agri-food production around the world. Little is known, however, about how participation in AGVCs changes the structure of participating economies. Using a constructed panel dataset from 155 countries for the period 1991-2015, I find that, in response to high AGVC participation, both GDP and employment shares in the agricultural and services sectors increase, and that both factors decrease in the manufacturing sector. Counter to conventional wisdom about structural transformation, I uncover evidence that modern agrarian economies are leapfrogging the manufacturing sector to directly develop their agriculture and services sectors through their participation in AGVCs.

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1 Introduction

Global value chains (GVCs) have changed the nature of production around the world. Historically, firms produced goods from start to finish in one country, and countries traded finished goods with other countries. Nowadays, however, it is uncommon for international trade transactions to be based on the exchange of finished goods. Rather, sales of individual components of products and value-added intermediate services dominate most of what is being traded, and over 70 percent of today's international trade involves GVCs wherein services, raw materials, parts, and components cross borders—often numerous times. Once those services, raw materials, parts, and components are incorporated into final products, those final products are shipped to consumers all over the world. As a result, "Made in" labels have become symbols of a bygone era because the disintegration of production processes across borders has gradually spread in the modern economy (Antras, 2016).

In modern production, a single finished product often results from a multinational supply chain wherein each step in the process adds value to the final product—a so-called global value chain. Global value chain refers to the sequence of dispersed activities in several countries involved in transforming raw materials into final consumer products, including production, marketing, distribution, and support to the end users (Gereffi and Fernandez-Stark, 2011). In other words, a GVC is a sequence of all functional activities required in the process of value creation by more than one country.

Since the mid-1900s, agricultural GVCs (hereafter AGVCs) have grown rapidly. From the 1950s to the 1980s, agricultural industries were in a period of pre-globalization, shifting from traditional, small-scale, and informal to larger-scale, more formal industries. Since the early 1990s, when trade liberalization expanded with China's emergence as a major participant in world trade, countries have modernized their agricultural GVCs (Reardon et al., 2009). Moreover, through rapid vertical integration, leading global grocery processors and retailers have emerged as dominant players in AGVCs by linking farmers up-

stream with customers downstream (Sexton, 2013).

Here I investigate how AGVC participation transforms the structure of agrarian economies. Since Kuznets and Murphy (1966), structural transformation—wherein a country reallocates its economic activities from the agricultural sector to the manufacturing and services sectors—has received a lot of attention in policy debates surrounding economic growth in both developed and developing countries. Although the rise of GVCs has changed modern agricultural production systems, it is unclear whether and how the rise of AGVCs has affected the economic structure of participating countries (Barrett et al., 2019). One scenario is that countries allocate more economic resources to the agricultural sector from the non-agricultural sector because more AGVC participation might increase agrarian export volume by adding value in supply chains. A second scenario is that countries reallocate economic resources from the agricultural sector to non-agricultural sectors such as manufacturing or services. This scenario is often supported by the view that some countries outsource agricultural production from other countries and focus more on food processing and labeling in downstream value chains.

I begin by assessing whether AGVC participation affects structural transformation at the country level. To do so, I use data on 155 countries over the period 1991-2015 to look specifically at whether participation in AGVCs changes the GDP and employment shares of the agricultural, manufacturing, and services sectors. In order to measure AGVC participation at the country level, I first apply the bilateral gross exports decomposition method developed recently by Wang et al. (2017) to the EORA multi-region input-output tables. I then rely on country and year fixed effects to look at whether AGVC participation is associated with changes in the GDP and employment shares of each sector.

I find that, on average, in the response to greater AGVC participation, a country tends to become more agrarian. Both GDP share and employment share in the agricultural sector are positively associated with an increase in AGVC participation. However, individual countries also tend to become less industrial and more services-based. Both GDP and employment shares in manufacturing decrease as the country increases its participation

in AGVCs, while in the services sector more participation in AGVCs is positively and significantly associated with the GDP share and the employment share. These findings suggest that modern agrarian economies are leapfrogging the manufacturing sector to directly develop their services sector through greater participation in AGVCs. This result runs counter to conventional wisdom about structural transformation. In examining the heterogeneous effects of AGVC participation, I find that the core results of structural transformation appear to be driven by high-income countries.

I further analyze whether positioning in AGVCs matters for structural transformation. After decomposing the total AGVC participation into upstream participation and downstream participation in AGVCs, I find that the core leapfrogging result remains robust both upstream and downstream. However, when GDP shares are the outcomes under consideration, upstream participation in AGVCs is associated with a more agrarian economy; when employment shares are the outcomes, downstream participation in AGVCs is associated with a more agrarian economy. This finding implies that upstream (downstream) participation leads to more labor- (capital-) intensive agriculture.

The contribution of this study is threefold. First, it contributes broadly to the literature on the consequences of trade liberalization. Since the late 1940s, world trade has rapidly liberalized, along with successive rounds of trade negotiation by the General Agreement on Tariffs and Trade (GATT) and its successor, the World Trade Organization (WTO). Unlike the manufacturing and services sectors, the agricultural sector tends to be heavily protected by national agricultural policies in many developing countries (Reardon and Timmer, 2007; Sheldon, Chow and McGuire, 2018). By providing evidence that trade liberalization via AGVCs transforms the structure of economies, this study sheds light on the importance of AGVC for economic development.

This work also contributes more directly to the literature on agricultural value chains by looking at the relationship between agricultural trade and agricultural value chains. In the literature, numerous studies have studied the effects of participation in agricultural value chains by rural households, which stand at the very beginning of those value

chains, on a myriad of economic outcomes such as income, food security, and productivity (Mergenthaler, Weinberger and Qaim, 2009; Minten, Randrianarison and Swinnen, 2009; Bellemare, 2012; Cattaneo et al., 2013; Montalbano, Pietrelli and Salvatici, 2018). Although that literature is abundant, there are few empirical studies looking at the effect of participation in agricultural GVCs from the other end of agricultural value chains, viz. international trade (Balié et al., 2019*a*). This is because conventional trade data do not accurately present the extent of GVC participation, and measuring the extent of GVCs is in itself challenging (Koopman, Wang and Wei, 2014). The new method developed by Wang et al. (2017) combined with newly released multi-regional input-output (MRIO) data produces empirical evidence that can deepen our understanding of the relationship between agricultural value chains and trade from a global perspective.

Lastly, this study contributes to the literature on structural transformation by documenting that modern economies can transform their economies by going directly from agriculture to services via AGVCs. In the early literature, structural transformation was regarded as the key channel toward sustainable growth (Kuznets and Murphy, 1966; Syrquin, 1988). As economies developed, poor countries would reallocate their economic activities from agriculture to manufacturing and then services to attain higher levels of productivity, and historically that is how rich countries saw their economies evolve (Rogerson, 2008). As a result, manufacturing was prioritized as a key driver of structural transformation in poor agrarian countries (e.g., East Asia in the 1980s). More recent studies, however, provide evidence that the conventional structural transformation narrative has been less common for developing economies over the last two decades (Diao, McMillan and Rodrik, 2019; Newfarmer, Page and Tarp, 2019). With the rise of GVCs, many developing countries need to make more complex decisions about whether to prioritize manufacturing or to attempt to leapfrog manufacturing and go straight to services, which influences those countries' agricultural policies (Dasgupta and Singh, 2007; Rodrik, 2016). While numerous studies have discussed this new paradigm of structural transformation, few studies empirically show what drives the leapfrogging. The empirical findings here illustrate that.

The rest of the paper is organized as follows. Section 2 presents the data and discusses the descriptive statistics. Section 2.1 presents the empirical framework and the estimation results of the effects of AGVC participation on structural transformation. Section 4 assesses whether and how positioning in AGVCs is associated with structural transformation. Section 5 further explores the heterogeneous effects of AGVC participation by countries' income level and Section 6 concludes with policy implications.

2 Data and Descriptive Statistics

2.1 Agricultural Global Value Chains

In the trade literature, there have been two barriers to mapping GVCs. First, unlike conventional trade data that account for the final product transaction, measuring GVCs requires industry-level data, which enable one to track all value-added activities by the industry or country involved in global production. National accounts data (e.g., gross import or export of final products) are not suitable for measuring GVCs because those data lack information on the value added of intermediate input transactions. National input-output account data that describe value-chain linkages across industries can be considered as an alternative, but they only include value-added transactions within a country, not across countries (Johnson, 2018). In contrast, a multi-country, input-output table that combines the national input-output tables of various countries at a given point in time provides a comprehensive map of international transactions of goods and services (Inomata, 2017). Second, there is lack of agreement on a uniform way to measure GVCs. Researchers have struggled to conceptually define what types of value-added activities should be included (Hummels, Ishii and Yi, 2001; Johnson and Noguera, 2012; Johnson, 2018). International trade in value-added goods and services has become more complicated to track because GVC flows are heterogeneous, varying by commodity and by industry. As a result, decomposition of gross exports into various sources of value added is methodologically challeng-

ing.

To overcome these difficulties, I employ the EORA Multi-Region Input-Output Tables (MRIOs) generated by the UNCTAD-Eora Global Value Chain Database, to measure AGVC participation by adopting the new analytical conceptual framework proposed by Borin and Mancini (2019).[1] The framework captures all complicated sources of value-added activities across more than two countries, which are often missing in other measures of GVCs. It also provides an empirical method to extract value-added exports from gross exports, which enables users to identify each value-added activity by using cross-country input-output data.

Following the extensive literature on GVCs (Koopman, Wang and Wei, 2014; Los and Timmer, 2018; Wang et al., 2017; Belotti, Borin and Mancini, 2020), I decompose gross exports into three broad value-added activities. First, domestic value added (DVA) refers to the value of exports that is created by domestic production factors and contributes to gross domestic product (GDP) for each country. Second, foreign value added (FVA) is the value of exports that originates from imported inputs. FVA is considered a component of backward GVC participation (downstream). Lastly, domestic value added embedded in other countries' exports (DVX) refers to the domestic value added in intermediate goods that are further re-exported by the partner country. DVX is considered a component of forward GVC participation (upstream).

To measure GVC participation (D_{it}) for country i in year t, I follow Borin and Mancini (2019):

$$GVC\ Participation_{it} = \frac{DVX_{it} + FVA_{it}}{Gross\ Export_{it}}. \tag{1}$$

Similarly, upstream participation is measured by $\frac{DVX_{it}}{Gross\ Export_{it}}$ and downstream participation is measured by $\frac{DVX_{it}}{Gross\ Export_{it}}$.

To calculate total AGVC participation, I use the *agriculture* industry classification to

[1] For similar analytical frameworks that have been developed to measure supply and demand contributions of countries and sectors in GVCs, see Koopman, Wang and Wei (2014); Los and Timmer (2018); Wang et al. (2017)

measure agricultural GVCs and the *food & beverage* industry classification to measure food GVCs, respectively. The total AGVC participation is therefore defined as

$$AGVC\ participation_{it}^{Total} = \frac{DVX_{it}^{agr} + DVX_{it}^{food} + FVA_{it}^{agr} + FVA_{it}^{food}}{Gross\ Export_{it}^{agr} + Gross\ Export_{it}^{food}}. \quad (2)$$

Using the general cross-country input-output table from the UNCTAD-Eora Global Value Chain Database, I measure country-level GVC participation for 155 countries in the period 1991−2015. Specifically, I generate AGVC participation, foreign value added (FVA), and domestic value added first exported then returned home (DVX) for the agriculture industry and the food industry, respectively, by a STATA command of *icio* following Belotti, Borin and Mancini (2020).

TABLE 1: Summary Statistics: Agri-food GVC Participation (1991-2015, N=155 countries)

	N	Mean	S.D.	Min	Max	p25	Median	p75
Total								
AGVC participation (%)	3200	31.763	9.912	9.088	85.507	25.015	30.534	37.428
Downstream participation (FVA, %)	3200	15.671	10.132	.082	76.929	7.959	12.886	21.819
Upstream participation (DVX, %)	3200	16.091	7.47	3.578	53.649	11.06	14.79	19.894
Agricultural Industry								
AGVC participation (%)	3200	33.208	10.687	8.506	74.923	25.456	32.526	39.844
Downstream participation (FVA, %)	3200	10.913	7.51	.078	63.581	5.492	8.755	14.639
Upstream participation (DVX, %)	3200	22.296	8.303	4.149	67.814	16.602	22.388	27.178
Food Industry								
AGVC participation (%)	3200	30.91	10.273	9.693	87.333	23.474	29.544	36.639
Downstream participation (FVA, %)	3200	19.288	10.508	.133	80.974	11.458	16.827	25.16
Upstream participation (DVX, %)	3200	11.621	5.894	2.394	41.82	7.588	10.465	14.395

Notes: Data source from the UNCTAD-Eora Global Value Chain (GVC) database. GVC is measured by a GVC share of a country's gross exports following Koopman, Wang and Wei (2014). Downstream participation is measured by the foreign value added (FVA); upstream participation is measured by the domestic value added (DVX). "*Total* includes both agricultural industry and food industry by calculating $TotalAGVCparticipation = \frac{DVX_{agr}+DVX_{food}+FVA_{agr}+FVA_{food}}{GrossExport_{agr}+GrossExport_{food}}$.

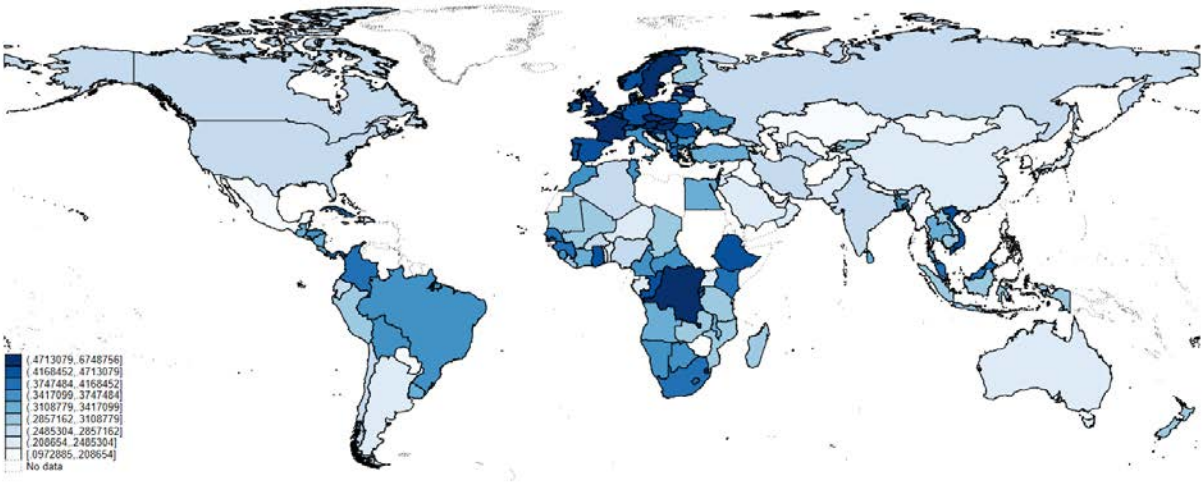
Table 1 reports summary statistics of AGVC participation for 155 countries in the period of 1991-2015. Across countries, the mean total AGVC participation was 31.7%; agricultural GVC participation (33.2%) was slightly larger than food GVC participation (30.9%). Total AGVC participation is almost equally distributed between downstream (15.67%) and

upstream (16.09%). However, in decomposing AGVC participation into agriculture and food industries, I find upstream participation (22.29) is approximately twice as great as downstream participation (10.91%) in agriculture, while downstream participation (19.28%) in the food industry is 1.6 times greater than upstream participation (11.62). In other words, GVCs in food and beverages likely have a larger share of backward linkages in production and relatively fewer forward linkages because the food and beverage industry involves a higher degree of foreign value added including processing, distributing, and labeling. The different pattern of average GVC participation between the agriculture and food industries is robust across years in the period 1991−2015 (see Appendix A.1).

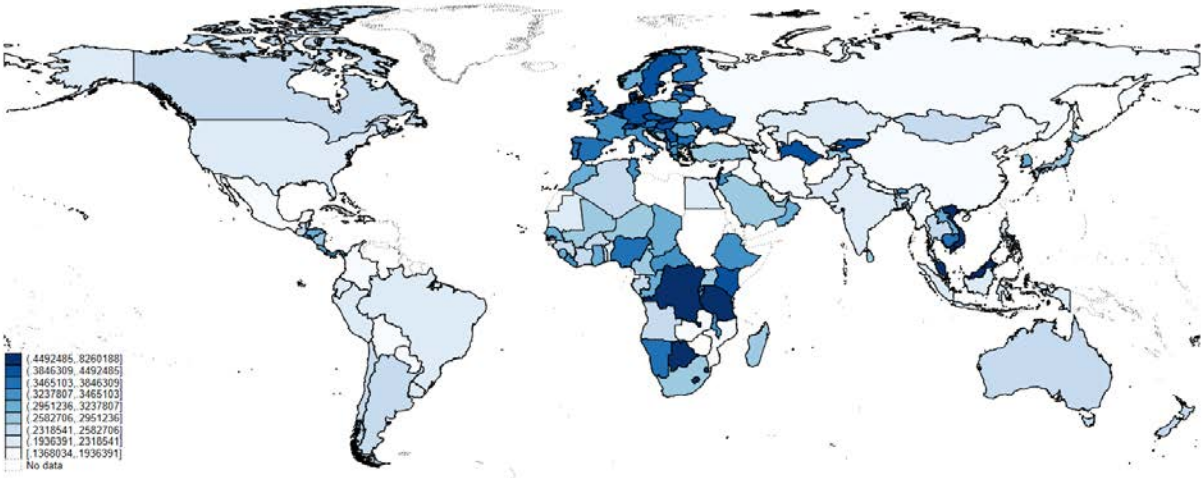
Figure 1 shows the geographical distribution of AGVC participation in the year 2015. European countries and sub-Saharan African (SSA) countries show a relatively high-level of GVC participation in both the agriculture and food industries. Also, European countries are more involved in downstream participation (backward linkages), while African countries are more involved in upstream participation (forward linkages) (see Figure 2). This AGVC participation pattern is likely to be driven by increasing demand from Europe for raw commodities produced in SSA in order to produce more processed food in Europe (Balié et al., 2019*a*,*b*; Feyaerts, Van den Broeck and Maertens, 2020).

FIGURE 1: Agrifood GVC participation across countries (Year 2015)

(a) Agriculture sector



(b) Food & beverages sector



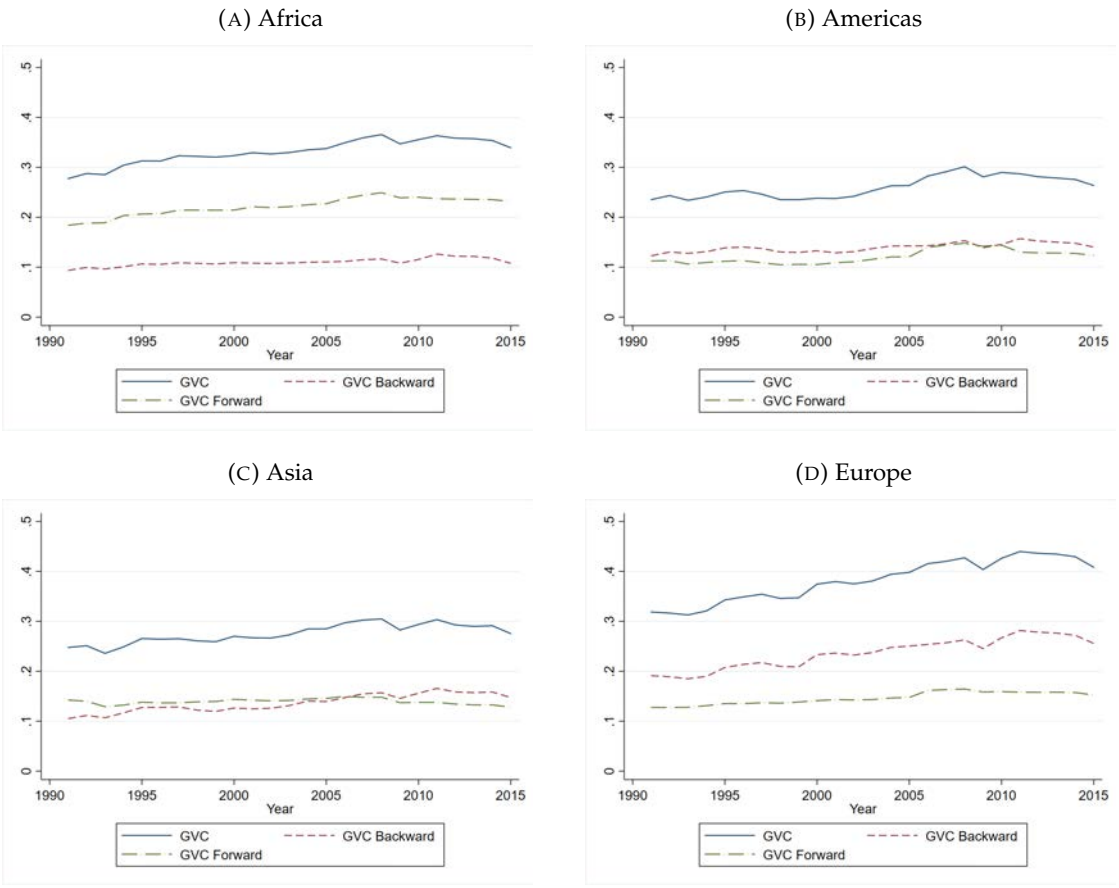
Notes: GVC participation rates in 2015. Panels (a) and (b) display GVC participation rate across countries in agriculture sector and food and beverages sector, respectively.

In Table A.1, I further provide summary statistics of AGVC participation by income-level. Following the World Bank classification, I calculate total AGVC participation, downstream participation, and upstream participation for four income groups: low, lower-middle, upper-middle, and high income.[2] I find three stylized facts: First, high-income

[2]The World Bank classifies economies for analytical purposes into four income groups by using gross national income (GNI) per capita data in U.S. dollars $ at year 2010: low income ($\leq 1,005$); lower middle income ($1,006 - 3,975$); upper middle income ($3,976 - 12,275$); high income ($> 12,275$).

countries' total AGVC participation (37.12%) is about 20% greater than that of relatively low-income countries. Second, as countries' income increases, downstream participation increases and upstream participation decreases. Third, relatively low-income countries participate more in the upstream agriculture industry than relatively higher-income countries, while relatively high-income countries participate more in the downstream food industry than relatively low-income countries.

FIGURE 2: Agricultural GVC participation by region (1991-2015)



Notes: For individual regions, I use the UN Standard Country Codes for Statistical Use (Series M, No. 49), a standard for area codes used by the United Nations for statistical purposes. Africa (Northern African, Sub-Saharan Africa); Americas (Northern America, Latin America and the Caribbean); Asia (Eastern Asia, Southern Asia, South-eastern Asia, Central Asia, Western Asia); Europe (Southern Europe, Eastern Europe including Northern Asia, Western Europe). Oceania (four countries) is excluded from the analysis.

2.2 Structural Transformation

The structural transformation of countries involves a variety of features. Following Timmer et al. (2009), structural transformation is characterized within a country by the following economic changes: (i) a falling share of agriculture in economic output and employment, (ii) a rising share of urban economic activity in industry or services, (iii) migration from rural to urban areas, (iv) a demographic transition from high birth rates to low death rates, and (v) declining female labor market participation in agriculture and rising female labor market participation in services.

In the growth and development literature, three measures of national economic activity by sectors (agriculture, manufacturing, and services) have been widely used: (i) GDP shares, (ii) employment shares, and (iii) final consumption shares (Herrendorf, Rogerson and Valentinyi, 2014). For instance, one can measure structural transformation in a country by looking at whether the share of agricultural activities decreases while the share of non-agricultural activities increases over the years.

I use GDP shares of agriculture, manufacturing, and services in each country as the main measure of structural transformation. To perform robustness checks, I use employment share by sector. I exclude final consumption shares as an alternative measure of structural transformation, however, for two reasons: First, it is difficult to obtain credible expenditure estimates for numerous developing countries (Ravallion, 2001). Second, measuring final consumption in the services sector has been proven to be perpetually challenging, and estimates are believed to be low, in both developing and developed countries (Landefeld, Seskin and Fraumeni, 2008). Thus, the measure of structural transformation is limited to production.

I use the World Development Indicators (WDI) database for GDP and employment shares in the agriculture, manufacturing, and services sectors, respectively.[3] Table 2 reports

[3]The agriculture sector corresponds to ISIC divisions 1-5, which include forestry, hunting, and fishing, as well as cultivation of crops and livestock production. Industry corresponds to ISIC divisions 10-45 including value added in mining, manufacturing, construction, electricity, water, and gas. Services correspond to ISIC divisions 50-99 including value added in wholesale and retail trade, transport, and government, financial, professional, and personal services such as education, health care, and real estate services.

GDP and employment shares by sectors for 155 countries from 1991 to 2015. Panel A shows that, on average, countries' GDP and employment shares in the agriculture sector decrease while GDP and employment shares in the services sector increase. In Panel B, we see that the economies of relatively high-income countries are more concentrated in the services sector and that relatively low-income countries focus their economic activities in the agriculture sector.

TABLE 2: Summary Statistics: Employment and GDP Share by Sector (N=155 countries)

		Employment Share (%)				GDP Share (%)			
	N	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max
Panel A: By time period									
1995-2002									
Agriculture sector (%)	3036	31.36	24.8	.22	92.37	14.21	12.66	.09	79.04
Manufacturing sector (%)	3036	20.74	9.06	1.86	43.13	27.98	10.29	3.24	84.8
Services sector (%)	3036	47.9	18.41	5.36	83.96	50.64	11.81	10.57	85.61
2003-2009									
Agriculture sector (%)	2844	27.85	23.63	.18	90.93	11.51	11.75	.05	72.24
Manufacturing sector (%)	2844	20.18	8.09	1.95	40.53	28.41	11.99	4.15	74.11
Services sector (%)	2844	51.97	18.18	6.66	86.62	52.61	11.67	20.76	90.29
2010-2015									
Agriculture sector (%)	2589	25.84	22.53	.19	88.22	10.98	11.13	.05	58.65
Manufacturing sector (%)	2589	19.74	7.87	2.06	54.14	27.75	12.25	4.56	74.81
Services sector (%)	2589	54.42	18.05	8.77	87.91	53.52	11.86	25.63	91.92
Panel B: By Income-level, 1995-2015									
Low Income									
Agriculture sector (%)	1674	64.73	16.93	29.31	92.37	31.92	10.55	14.06	79.04
Manufacturing sector (%)	1674	9.37	5.72	1.86	31.55	20.22	6.75	3.24	45.98
Services sector (%)	1674	25.9	12.96	5.34	62.41	42	8.76	12.44	67.59
Lower-Middle Income									
Agriculture sector (%)	2565	39.92	15.22	8.66	86.82	16.93	8.21	3.76	51.85
Manufacturing sector (%)	2565	18.22	6.25	2.8	38.3	30.28	11.2	14.16	84.8
Services sector (%)	2565	41.86	11.39	10.39	66.5	46.56	9.69	10.57	72.59
Upper-Middle Income									
Agriculture sector (%)	2685	21.3	12.04	.26	59.7	7.89	4.62	1.83	36.41
Manufacturing sector (%)	2685	23.33	6.17	9.44	40.29	31.16	9.78	8.41	66.16
Services sector (%)	2685	55.38	11.18	18.9	78.8	53.24	9.34	21.76	75.41
High Income									
Agriculture sector (%)	2676	5.23	3.92	.18	22.88	2.3	1.45	.05	7.98
Manufacturing sector (%)	2676	25.9	6.73	9.19	54.14	28.11	12.64	6.72	74.81
Services sector (%)	2676	68.87	8.72	43.99	87.91	60.94	10.47	25.25	91.92

Notes: The World Bank defines four income categories based on GNI per capita in US$ in the year 2010: low income ($\leq 1,005$); lower middle income ($1,006 - 3,975$); upper middle income ($3,976 - 12,275$); high income ($> 12,275$). GDP and employment share data are sourced from the World Development Indicator database.

2.3 Other Control Variables

To account for potential confounders, I include a broad set of country-level demographic, socioeconomic, and trade covariates, guided by the considerable empirical literature on determinants of structural transformation. To control for demographics, I include population share by age group and gender. To control for urbanization (Michaels, Rauch and Redding, 2012), I also include both rural and urban population shares. To control for differences in economic composition across countries, I include GDP, GDP growth, net trade proportion of GDP, inflation GDP deflator, proportion of export/import of goods and services, and self-employed rate. To control for differences in agricultural production across countries, I further include a subset of agrarian covariates, including land area (agricultural land area, arable land, land under cereal production) and agricultural production by commodity (cereal, fisheries, livestock, and food). For all of these variables, I use the WDI database at the country level from 1991 to 2015.

Combining these covariates, I further control for differences in trade activities across countries. Using Mario Larch's Regional Trade Agreements Database, I include a subset of trade agreement variables-regional trade agreement (RTA), customs union (CU), free trade agreement (FTA), partial scope agreement (PTA), and economic integration agreement (EIA)-in the form of the numbers of each agreement and binary variables for each country in a year.[4] Table A.2 displays the list of all time-varying control variables in the sample.

[4]Mario Larch's Regional Trade Agreements Database includes all multilateral and bilateral regional trade agreements as notified to the World Trade Organization (WTO) from 1950 to 2019(Egger and Larch, 2008). See https://www.ewf.uni-bayreuth.de/en/research/RTA-data/index.html.

3 AGVC Participation and Structural Transformation

In Section 3.1, I present the preferred empirical specification based on standard linear regression methods with country and year fixed effects. I next discuss the identification strategy by explaining how the empirical approach addresses the main sources of endogeneity in Section 3.2. In Section 3.3, I discuss the core estimation results.

3.1 Baseline Regression Model

The equation of interest is

$$y_{it} = \alpha + \beta AGVC_{it} + X_{it}\delta + \gamma_i + \mu_t + \varepsilon_{it}. \tag{3}$$

y_{it} is a sector share (agriculture, manufacturing, or services) for country i in year t. This is a percentage outcome, taking on a value between 0 and 100; D_{it} is the treatment variable (i.e., the level of participation in agricultural GVCs of country i in year t); X_{it} denotes time-varying control variables; γ_i denotes a vector of country fixed effects; μ_t denotes a vector of year fixed effects. λ_i is a country-specific time trend and it is an error term with mean zero. I estimate Equation 3 using ordinary least squares.

Country fixed effects (γ_i) are included to control for time invariant unobserved heterogeneity within each country i. Year fixed effects (μ_t) control for all the country-invariant unobserved heterogeneity within each year. I cluster the standard errors by country following the recommendations in Abadie et al. (2017). The goal in this study is to estimate β to show the effect of participation in agricultural GVCs on structural transformation by testing the null hypothesis $H_0 : \beta = 0$ versus the alternative hypothesis $H_A : \beta \neq 0$

3.2 Endogeneity Issues

Because the extent of GVCs participation by a country is not randomly assigned, and therefore the treatment is not exogenous to structural transformation measured in GDP shares

by sector, it is important to discuss potential threats to identification. I discuss the identification strategy by addressing three broad sources of endogeneity: unobserved heterogeneity, measurement error, and reverse causality.

Unobserved Heterogeneity

To properly identify the average treatment effect, a linear regression should include all potential confounders-i.e., all of the variables that cause both the outcome and the treatment. Although it is generally not feasible to account for all omitted variables, in many cases it is important to identify and include potential unobserved confounders.

In the empirical framework, multiple tactics are deployed to minimize unobserved heterogeneity. First, the country-fixed effects used in the baseline specification are expected to control for the time-invariant factors in each country. The time-invariant factors include country-specific geographical conditions and socio-cultural backgrounds, such as language or history, which have been deemed determinants of trade volumes or economic growth. Country fixed effects also control for initial economic conditions (e.g., levels of GDP in the initial year in the panel data) in each country, which often determine the pattern of structural transformation of a country (De Vries, Timmer and De Vries, 2015; Hnatkovska, Lahiri and Vegh, 2016; Bustos, Caprettini and Ponticelli, 2016). Second, year fixed effects purge the error term of its correlation with the treatment variable owing to factors that are constant across all countries in a given year. For example, progress on structural transformation might have been slowed in 2008-2009 because of the global financial crisis.

Further, I include a broad set of country-level demographic and economic covariates, guided by the considerable empirical literature on structural transformation (Michaels, Rauch and Redding, 2012; Bustos, Caprettini and Ponticelli, 2016; Duarte and Restuccia, 2010; Alvarez-Cuadrado and Poschke, 2011). To control for demographics, I include population shares by age group, gender, rural population, and urban population. To control for differences in economic composition across countries, I also include GDP growth, inflation GDP deflator, GDP, trade share in GDP, exports of goods and services, and self-employed

share. One might be concerned that the extent of participation in agricultural GVCs is endogenous because of changes in trade policy within a country, trade competitiveness with other countries, or domestic agricultural price policy. To control for time-varying trade policy and competitiveness conditions, a vector X_{it} also contains regional trade agreements, customs unions, free trade agreements, partial scope agreements, and economic integration agreements. Various agricultural covariates are also included to control for time-varying production conditions.

Although most of unobserved confounders that mar the identification of the causal effect of GVC participation on the measures of structural transformation can be captured by the various means described above, the identifying assumption one needs to make in order to make a causal statement about the relationship between GVC participation and structural transformation is that whatever unobserved confounders are left do not significantly bias the estimate of β. This is an assumption that I am unwilling to make, and so for the remainder of this paper I talk about the association between GVC participation and structural transformation, and interpret the estimates as only suggestive of a causal relationship.

Measurement Error

Another source of endogeneity is measurement error, especially in fixed-effects regressions such as those used here, wherein one should avoid overly strong claims when interpreting estimates given that the data might have systematic errors, such as under- or over-reporting. In measuring the extent of GVCs, missing information on the division between intermediate and final goods can be a source of measurement error. This is because there are heterogeneous product codes in cross-border supply chains. Although there are a few trials to measure the extent of GVCs in the literature, the existing measures are still not free from the measurement error issue.

The treatment variable is the extent of agricultural GVC participation in each country, and it is measured using the recent measure developed by Wang et al. (2017). Their measure eliminates the aforementioned missing information source by decomposing value-

added production activities in cross-border production. Also, it provides measures of upstream and downstream GVC participation, which show a much more detailed GVC involvement than other measures (see Antras and Chor (2018). Thus, I rely on the proven validity of the measure of GVCs (Antràs, De Gortari and Itskhoki, 2017; Antras and Chor, 2018; Balié et al., 2019*a*) to obviate concerns about measurement error in the treatment variable.

Another concern is measurement error related to the measures of structural transformation. Recall that I use the GDP (or employment) share of each of the three sectors of the economy (i.e., agriculture, manufacturing, services) for each country over the years as a primary measure of structural transformation. The longitudinal data I use were assembled from the statistical offices in 155 countries. Although the estimates of GDP (or employment) shares are reliable in most developed countries, they are likely to be measured with error in many developing countries (Jerven, 2013; De Vries, Timmer and De Vries, 2015). For example, in various African countries large measurement errors in estimating GDP are due to the low quality of statistical management—a phenomenon that has been referred to as "Africa's statistical tragedy" (Devarajan, 2013; Jerven and Johnston, 2015).

There is no evidence, however, that GDP (or employment) shares are systematically over-or under-estimated; the measurement error I face in this case is classical measurement error, and so the estimate of β may suffer from attenuation bias. This implies that a rejection of the null hypothesis provides stronger evidence than in the absence of measurement error and that the estimate $\hat{\beta}$ is the lower bound (in absolute value) of the true coefficient of β.

Reverse Causality

The third endogeneity concern stems from reverse causality. If structural transformation leads to changes in participation in agricultural GVCs and y_{it} and D_{it} are thus jointly determined, the estimate of β would thus be biased. Structural transformation is, however, unlikely to be a dominant influence on GVC participation. Indeed, for a given country in a given year, trade activity occurs before GDP is calculated; therefore reverse causality,

wherein GDP shares drive participation in agricultural GVCs, is not a concern.

3.3 Estimation Results

Table 3 reports the core results for 155 countries for the period 1991-2015. Panel 1 and Panel 2 in Table 3 present the estimation results for GDP shares and the employment shares, respectively. Estimation results for the agricultural sector, the industry sector, and the services sector are reported in Columns (1)(2), (3)-(4), and (5)-(6), respectively with country and year fixed effects of Equation 3. In Columns (1), (3), and (5), I exclude time-varying control variables, while columns (2), (4), (6) are the full specifications as in Equations 3.

TABLE 3: The Effects of AGVC Participation on Structural Transformation, Total

	Structural transformation measured by GDP or employment share by sector (%)					
	Agriculture		Industry		Service	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: GDP Share						
AGVC participation (%)	.11***	.039***	-.179***	-.338***	.003	.112***
	(.013)	(.014)	(.02)	(.023)	(.022)	(.025)
N	3200	3200	3200	3200	3200	3200
R^2	.958	.97	.95	.966	.959	.971
Panel B: Employment Share						
AGVC participation (%)	.206***	.006	-.365***	-.151***	.159***	.144***
	(.022)	(.016)	(.021)	(.019)	(.017)	(.019)
N	3200	3200	3200	3200	3200	3200
R^2	.983	.995	.895	.95	.99	.993
Country & Year FE	yes	yes	yes	yes	yes	yes
Covariates		yes		yes		yes

Notes: All regression specifications include country fixed effects and year fixed effects. Country-level characteristics include population bins (by age, by gender, rural and urban population ratio), agricultural production conditions (arable land, agricultural land, total land area, food production index, livestock production index, land under cereal production, total cereal production, total fisheries production), and economic characteristics (GDP, GDP growth, inflation GDP deflator, trade proportion (%), exports of goods and services, self-employment total). Trade policy controls include the number of 5 types of trade agreements and a binary variable for each trade agreement (RTA, CU, FTA, PSA, EIA). A full list of variables included in the regression can be found in the Appendix Table A.2. Standard errors clustered at the country level are in parentheses. $^{***}p < 0.01; ^{**}p < 0.05; ^{*}p < 0.1$

Panels A and B show that, as a country's participation in AGVCs increases, that country tends to become more agrarian on average. Both GDP share and employment share in the agricultural sector are positively associated with an increase in AGVC participation. That

country also tends to become less industrial. Columns (3)-(4) show that, in response to a 1 percentage point increase in the AGVC participation rate, the industry sector GDP share decrease ranges from 0.179 to 0.338. Surprisingly, the estimation results in Columns (5)-(6) show that more participation in AGVCs is positively and significantly associated with the GDP share and employment share in the services-based sector.

This result points to a hollowing out of the middle of the economic structure (i.e., the industrial sector). More importantly, it points to a leapfrogging by the average economy over the industrial sector. This finding suggests that modern agrarian economies are moving directly from agriculture to developing their services sector as a consequence of greater participation in AGVCs. This core result runs counter to conventional wisdom about structural transformation.

Recall that the AGVC participation measure in this study includes two agri-food sectors (*agriculture* and *food & beverage*). To check whether the patterns of structural transformation are different in different agri-food sectors, I separate total agricultural GVCs into agriculture and food sectors and report the estimation results in Table 4.

In all cases, the core results are robust. Increased participation in AGVCs-measured by either GDP shares or employment shares, and looking at either agriculture or the food industry-is associated with a hollowing out of the middle industrial sector of the economy. However, Column (2) shows that the GDP share or employment share in the agricultural sector increases only in the agricultural industry while the effects in the food & beverage industry remain the same. This finding implies that GVC participation in the food & beverage industry leads countries more directly to structural transformation as they leapfrog the industrial sector and develop the services sector instead.

TABLE 4: The Effects of AGVC Participation on Structural Transformation by Industry

	Structural transformation measured by GDP or employment share by sector (%)					
	Agriculture		Industry		Service	
Panel A: Agriculture Industry	(1)	(2)	(3)	(4)	(5)	(6)
Panel A.1: GDP Share						
AGVC participation (%)	.115***	.055***	-.255***	-.315***	.046*	.095***
	(.018)	(.019)	(.023)	(.025)	(.025)	(.027)
N	3200	3200	3200	3200	3200	3200
R^2	.954	.966	.948	.962	.961	.972
Panel A.2: Employment Share						
AGVC participation (%)	.164***	.033*	-.402***	-.198***	.238***	.165***
	(.027)	(.018)	(.025)	(.02)	(.019)	(.019)
N	3200	3200	3200	3200	3200	3200
R^2	.984	.995	.886	.951	.992	.994
Panel B: Food&Beverage Industry						
Panel B.1: GDP Share						
AGVC participation (%)	.067***	.012	-.103***	-.247***	-.002	.084***
	(.009)	(.01)	(.018)	(.02)	(.019)	(.022)
N	3200	3200	3200	3200	3200	3200
R^2	.96	.974	.951	.967	.957	.97
Panel B.2: Employment Share						
AGVC participation (%)	.16***	-.006	-.265***	-.083***	.105***	.089***
	(.018)	(.014)	(.018)	(.017)	(.015)	(.017)
N	3200	3200	3200	3200	3200	3200
R^2	.981	.995	.899	.949	.989	.992
Country & Year FE	yes	yes	yes	yes	yes	yes
Covariates		yes		yes		yes

Notes: All regression specifications include country fixed effects and year fixed effects. Country-level characteristics include population bins (by age, by gender, rural and urban population ratio), agricultural production conditions (arable land, agricultural land, total land area, food production index, livestock production index, land under cereal production, total cereal production, total fisheries production), and economic characteristics (GDP, GDP growth, inflation GDP deflator, trade proportion (%), exports of goods and services, self-employment total). Trade policy controls include the number of 5 types of trade agreements and a binary variable for each trade agreement (RTA, CU, FTA, PSA, EIA). A full list of variables included in the regression can be found in Appendix Table A.2. Standard errors clustered at the country level are in parentheses. $^{***}p < 0.01; ^{**}p < 0.05; ^{*}p < 0.1$

4 Does positioning in AGVCs matter for structural transformation?

Here I further assess whether positioning in AGVCs is associated with structural transformation. As described in Section 2.1, downstream participation is measured by the foreign value added (FVA) while upstream participation is measured by the domestic value added (DVX). After decomposing total AGVC participation into upstream (forward linkages) and downstream (backward linkages) participation, I run the following regression similar to Equation 3 to analyze whether the type of GVC participation (or positioning) matters for structural transformation:

$$y_{it} = \alpha + \beta_1 GVC_{it}^{up} + \beta_2 GVC_{it}^{down} + X_{it}\delta + \gamma_i + \mu_t + \varepsilon_{it}, \tag{4}$$

where GVC_{it}^{up} is upstream participation, as measured by DVX (%) and GVC_{it}^{down} is downstream participation, as measured by FVA (%).

Table 5 presents the estimation results of AGVC positioning. Panels A, B, and C reports estimation results for total AGVC participation, agricultural industry, and food industry, respectively. One thing that immediately jumps out is that both upstream and downstream participation in AGVCs are associated with a leapfrogging of the industrial sector to directly develop the services sector. When considering GDP shares as outcomes, upstream participation in AGVCs is associated with a more agrarian economy. When considering employment shares as outcomes instead, it is downstream participation in AGVCs that is associated with a more agrarian economy. This finding suggests that upstream (downstream) participation leads to more labor- (capital-) intensive agriculture.

TABLE 5: The Effects of AGVC Positioning on Structural Transformation

	Dependent variable: Structural transformation (share by sector)					
	GDP share (%)			Employment share (%)		
	Agr	Ind	Srv	Agr	Ind	Srv
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Total						
Upstream participation (DVX, %)	3.916***	-33.867***	11.626***	1.095	-15.564***	14.458***
	(1.437)	(2.272)	(2.526)	(1.597)	(1.939)	(1.89)
Downstream participation (FVA, %)	2.905	-34.675***	30.424***	19.626***	-36.352***	16.717***
	(3.362)	(5.315)	(5.909)	(3.735)	(4.535)	(4.42)
N	3200	3200	3200	3200	3200	3200
R^2	.97	.966	.971	.995	.95	.993
Panel B: Agriculture Industry						
Upstream participation (DVX, %)	6.11***	-33.875***	4.826*	-.024	-14.954***	14.975***
	(2.01)	(2.636)	(2.878)	(1.936)	(2.133)	(2.067)
Downstream participation (FVA, %)	3.844	-24.664***	22.519***	12.547***	-33.292***	20.747***
	(2.766)	(3.627)	(3.96)	(2.663)	(2.935)	(2.843)
N	3200	3200	3200	3200	3200	3200
R^2	.966	.962	.972	.995	.952	.994
Panel C: Food Industry						
Upstream participation (DVX, %)	1.797*	-25.193***	9.324***	.58	-9.874***	9.277***
	(1.054)	(2.032)	(2.251)	(1.369)	(1.767)	(1.73)
Downstream participation (FVA, %)	10.434***	-31.989***	23.222***	18.783***	-33.939***	15.136***
	(3.179)	(6.13)	(6.793)	(4.129)	(5.333)	(5.219)
N	3200	3200	3200	3200	3200	3200
R^2	.974	.967	.97	.995	.95	.992
Country & Year FE	yes	yes	yes	yes	yes	yes
Covariates	yes	yes	yes	yes	yes	yes

Notes: Following Koopman, Wang and Wei (2014), downstream participation is measured by the foreign value added (FVA); upstream participation is measured by the domestic value added (DVX). "*Total*" includes both agricultural industry and food industry by calculating $TotalAGVCparticipation = \frac{DVX_{agr}+DVX_{food}+FVA_{agr}+FVA_{food}}{GrossExport_{agr}+GrossExport_{food}}$. All regression specifications include country fixed effects and year fixed effects. Country-level characteristics include population bins (by age, by gender, rural and urban population ratio), agricultural production conditions (arable land, agricultural land, total land area, food production index, livestock production index, land under cereal production, total cereal production, total fisheries production), and economic characteristics (GDP, GDP growth, inflation GDP deflator, trade proportion (%), exports of goods and services, self-employment total). Trade policy controls include the number of 5 types of trade agreements and a binary variable for each trade agreement (RTA, CU, FTA, PSA, EIA). A full list of variables included in the regression can be found in Appendix Table A.2. Standard errors clustered at the country level are in parentheses. $^{***}p < 0.01; ^{**}p < 0.05; ^{*}p < 0.1$

5 Treatment Heterogeneity by Income Level

This section examines the heterogeneous effects of AGVC participation by country income level. Following the World Bank Analytical Classifications, I use four income categories that are based on GNI per capita in US$ in 2010 (i.e., low income (1,005); lower-middle

income (1,0063,975); upper-middle income (3,97612,275); high income (>12,275)). Table 5 reports the estimation results.

TABLE 6: The Effects of AGVC Participation on Structural Transformation by Income

	Dependent variable: Structural transformation (share by sector)					
	GDP share (%)			Employment share (%)		
	Agr	Ind	Srv	Agr	Ind	Srv
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Low-income countries						
AGVC Participation (%)	15.428	-28.038***	28.357***	-20.004***	10.133***	9.861***
	(11.43)	(6.707)	(10.065)	(6.147)	(3.454)	(3.359)
N	558	558	558	558	558	558
R^2	.829	.873	.753	.976	.958	.986
Panel B: Low-middle income countries						
AGVC Participation (%)	4.499	-46.479***	16.537***	-7.38**	1.62	5.744**
	(3.558)	(4.106)	(4.302)	(3.112)	(1.732)	(2.523)
N	855	855	855	855	855	855
R^2	.9	.933	.903	.983	.962	.986
Panel C: Middle-high income countries						
AGVC Participation (%)	15.446***	-31.863***	-20.097***	17.949***	-28.387***	10.457**
	(3.693)	(5.522)	(6.231)	(4.805)	(3.722)	(4.319)
N	895	895	895	895	895	895
R^2	.926	.974	.944	.992	.946	.994
Panel D: High income countries						
AGVC Participation (%)	5.351***	-37.379***	24.74***	8.286***	-33.785***	25.47***
	(.996)	(3.871)	(4.066)	(1.66)	(3.824)	(3.896)
N	892	892	892	892	892	892
R^2	.949	.964	.969	.974	.968	.978
Country & Year FE	yes	yes	yes	yes	yes	yes
Covariates	yes	yes	yes	yes	yes	yes

Notes: The World Bank defines four income categories based on GNI per capita in US$ in year 2010: low income ($\leq 1,005$); lower middle income ($1,006 - 3,975$); upper middle income ($3,976 - 12,275$); high income ($> 12,275$). GDP and employment shares data are sourced from the World Development Indicator database. All regression specifications include country fixed effects and year fixed effects. Country-level characteristics include population bins (by age, by gender, rural and urban population ratio), agricultural production conditions (arable land, agricultural land, total land area, food production index, livestock production index, land under cereal production, total cereal production, total fisheries production), and economic characteristics (GDP, GDP growth, inflation GDP deflator, trade proportion (%), exports of goods and services, self-employment total). Trade policy controls include the number of 5 types of trade agreements and a binary variable for each trade agreement (RTA, CU, FTA, PSA, EIA). A full list of variables included in the regression can be found in the Appendix Table A.2. Standard errors clustered at the country level are in parentheses. $^{***}p < 0.01; ^{**}p < 0.05; ^{*}p < 0.1$

The estimation results in Table 5 suggest that our average findings from the core results involve heterogeneity. Panels C and D appear to show that the core results of structural transformation in response to greater AGVC participation are driven by high-income countries. Outside of that high-income category, the findings seem to be highly dependent on the type of country considered. For example, employment shares in low-income and low-middle-income countries in particular, seem to follow the conventional structural transformation narrative.

6 Concluding Remarks

This paper is the first to investigate the relationship between the extent of a country's participation in agricultural GVCs and the structural transformation of its economy. I have looked at the relationship between agricultural GVC participation on the one hand and at how the reallocation of economic activities affects the shares of GDP and employment in the agricultural, manufacturing, and services sectors on the other hand. Using cross-country data from 155 countries for the period 1991-2015, I find that modern economies leapfrog the manufacturing sector, choosing instead to reallocate economic activity to their agricultural and services sectors as their participation in agricultural GVCs becomes more extensive. This result is robust, and the results seem driven by high-income countries rather than by developing countries. This runs counter to conventional wisdom about structural transformation.

The findings in this study can help inform agricultural trade policy in two ways. First, policy makers may wish to focus on participation in global agricultural production if their goal is to transform their economies by reallocating resources across sectors. In debates about Brexit, the re-design of the North American Free Trade Agreement, and the recent trade war between the US and China, trade policies aimed at protecting domestic agriculture from agricultural imports have featured prominently. This perspective seems to reflect a tacit expectation that GVC linkages alter the conventional calculus of trade pro-

tection (Blanchard, Bown and Johnson, 2017). The results suggest that trade liberalization through agricultural GVCs can lead to structural transformation in the same way that a country can reallocate its economic resources into non-agricultural sectors, which has been seen as a main driver of economic growth.

Second, although it may be tempting for governments to foster participation in GVCs with an eye toward structural transformation, policy makers should be cautious when trying to open up their agricultural markets. The results here suggest that a country is able to transition its economy out of agriculture when the country participates in GVCs by producing intermediate inputs related to manufacturing and services but not in the agriculture sector. Given that many poor developing countries have a competitive advantage in agriculture rather than manufacturing or service, they may be tempted to consider participating in agricultural GVCs by allocating more agricultural resources to intermediate production for export. Although doing so might result in higher overall GDP or employment, it is unlikely to transform an economy into one primarily based on manufacturing and services. Trade policies should therefore be designed to improve manufacturing or services related domestic activities in intermediate agricultural production.

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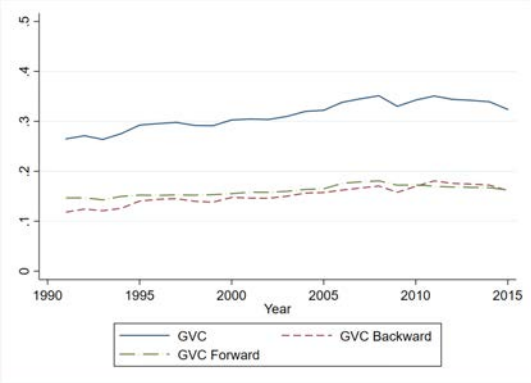
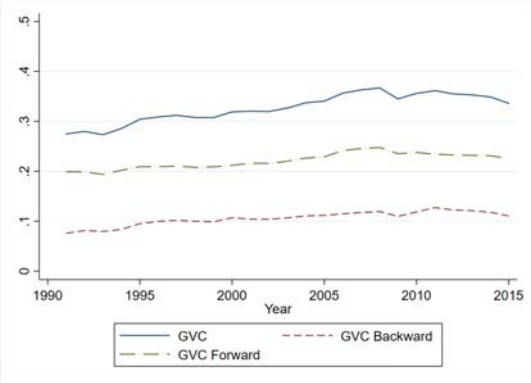
Appendix

FIGURE A.1: Average GVC participation Trends, 1991-2015 (%, N= 155 countries)

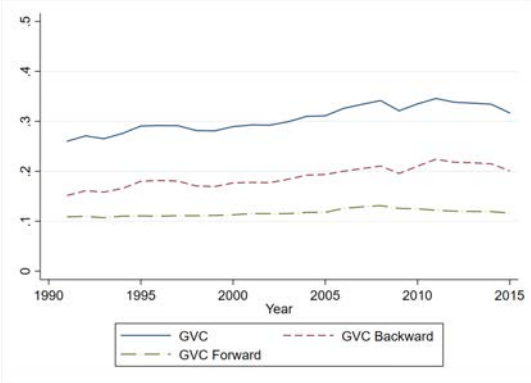
(A) Total Agrifood Industry



(B) Agriculture Industry



(C) Food Industry



Notes: Data are sourced from the UNCTAD-Eora Global Value Chain (GVC) database. GVC is measured by the GVC share of a country's gross exports following Koopman, Wang and Wei (2014). Downstream participation is measured by the foreign value added (FVA); upstream participation is measured by the domestic value added (DVX). "*Total* includes both agricultural industry and food industry by calculating $TotalAGVCparticipation = \frac{DVX_{agr}+DVX_{food}+FVA_{agr}+FVA_{food}}{GrossExport_{agr}+GrossExport_{food}}$.

TABLE A.1: Summary Statistics: Agri-food GVC Participation by Income Level, 1991-2015

	N	Mean	S.D.	Min	Max	p25	Median	p75
Panel 1.1: Low income								
Total								
AGVC participation (%)	558	30.73	8.856	9.088	60.07	25.425	29.905	35.48
Downstream participation (%, FVA)	558	8.404	4.663	.082	32.049	5.307	7.701	10.102
Upstream participation (%, DVX)	558	22.326	8.998	4.476	48.711	17.056	21.162	27.438
Agricultural Industry								
AGVC participation (%)	558	31.304	9.726	8.506	61.866	25.298	30.632	38.423
Downstream participation (%, FVA)	558	6.123	4.041	.078	30.592	3.846	5.051	7.227
Upstream participation (%, DVX)	558	25.181	9.968	4.396	52.384	18.407	23.525	32.157
Food Industry								
AGVC participation (%)	558	30.165	8.872	13.051	57.649	23.183	29.529	35.915
Downstream participation (%, FVA)	558	14.004	6.667	.133	44.47	10.03	12.541	17.232
Upstream participation (%, DVX)	558	16.161	7.637	3.512	41.82	11.063	14.732	20.688
Panel 1.2: Lower-middle income								
Total								
AGVC participation (%)	855	29.5	7.706	13.302	53.724	23.974	29.222	33.786
Downstream participation (%, FVA)	855	11.821	7.062	2.394	45.829	6.779	9.828	15.618
Upstream participation (%, DVX)	855	17.679	7.262	4.532	40.024	11.852	17.036	21.714
Agricultural Industry								
AGVC participation (%)	855	30.784	8.545	12.769	54.559	24.141	31.641	35.852
Downstream participation (%, FVA)	855	7.535	4.56	1.507	38.494	4.967	6.185	9.09
Upstream participation (%, DVX)	855	23.248	8.048	8.198	42.729	16.142	23.51	28.532
Food Industry								
AGVC participation (%)	855	28.05	7.883	13.68	55.956	22.504	26.495	32.549
Downstream participation (%, FVA)	855	15.634	7.977	3.98	50.742	9.781	13.384	20.616
Upstream participation (%, DVX)	855	12.416	5.7	3.338	28.888	7.249	11.811	16.434
Panel 1.3: Upper-middle income								
Total								
AGVC participation (%)	895	29.221	9.203	11.909	66.022	22.398	27.895	34.54
Downstream participation (%, FVA)	895	15.414	8.539	2.899	45.995	8.916	12.623	21.373
Upstream participation (%, DVX)	895	13.807	6.206	3.928	53.649	9.817	12.475	16.88
Agricultural Industry								
AGVC participation (%)	895	31.012	9.538	9.729	74.923	24.559	30.554	36.461
Downstream participation (%, FVA)	895	11.24	5.932	2.272	30.299	5.975	10.587	14.904
Upstream participation (%, DVX)	895	19.772	7.832	4.149	67.814	15.481	19.849	24.181
Food Industry								
AGVC participation (%)	895	28.544	10.081	9.693	64.449	20.808	26.984	34.84
Downstream participation (%, FVA)	895	18.825	9.809	3.285	58.482	11.248	15.884	25.097
Upstream participation (%, DVX)	895	9.719	4.749	2.394	40.936	6.498	9.325	11.707
Panel 1.4: High income								
Total								
AGVC participation (%)	892	37.127	10.997	13.791	85.507	29.5	36.641	42.849
Downstream participation (%, FVA)	892	24.166	10.698	5.775	76.929	16.933	23.067	28.339
Upstream participation (%, DVX)	892	12.961	4.329	3.578	27.556	10.319	12.875	15.873
Agricultural Industry								
AGVC participation (%)	892	38.928	12.006	13.052	71.916	28.13	39.857	46.555
Downstream participation (%, FVA)	892	16.818	8.758	3.518	63.581	10.795	15.79	20.434
Upstream participation (%, DVX)	892	22.11	7.018	4.389	35.518	16.994	23.576	27.029
Food Industry								
AGVC participation (%)	892	36.49	11.098	13.876	87.333	29.127	35.699	41.627
Downstream participation (%, FVA)	892	26.561	11.299	6.458	80.974	18.664	25.213	31.643
Upstream participation (%, DVX)	892	9.929	3.803	3.088	25.705	7.545	9.621	11.732

Notes: Data are sourced from the UNCTAD-Eora Global Value Chain (GVC) database. GVC is measured by the GVC share of a country's gross exports following Koopman, Wang and Wei (2014). Downstream participation is measured by the foreign value added (FVA); upstream participation is measured by the domestic value added (DVX). The World Bank defines four income categories based on GNI per capita in US$ in year 2010: low income ($\leq 1,005$); lower middle income ($1,006 - 3,975$); upper middle income ($3,976 - 12,275$); high income ($> 12,275$).

TABLE A.2: List of Control Variables

	Obs.	Data Source
Population ages 65 and above total	9600	World Development Indicator Database
Population ages 0-14 total	9600	World Development Indicator Database
Population ages 15-64 total	9600	World Development Indicator Database
Population female	9600	World Development Indicator Database
Rural population	9600	World Development Indicator Database
Urban population	9600	World Development Indicator Database
Arable land (hectares)	9600	World Development Indicator Database
Agricultural land (sq.km)	9600	World Development Indicator Database
Land area (sq. km)	9600	World Development Indicator Database
Food production index (2004-2006=100)	9600	World Development Indicator Database
Livestock production index (2004-2006=100)	9600	World Development Indicator Database
Land under cereal production (hectares)	9600	World Development Indicator Database
Cereal production (metric tons)	9600	World Development Indicator Database
Total fisheries production (metric tons)	9600	World Development Indicator Database
Capture fisheries production (metric tons)	9600	World Development Indicator Database
GDP growth (annual %)	9600	World Development Indicator Database
Inflation GDP deflator (annual %	9600	World Development Indicator Database
GDP (constant 2010 US$)	9600	World Development Indicator Database
Trade (% of GDP)	9600	World Development Indicator Database
Exports of goods and services (% of GDP)	9600	World Development Indicator Database
Self-employed total (% of total employment)	9600	World Development Indicator Database
Number of Regional Trade Agreements (RTA)	9600	Mario Larch's RTA Database
Number of Customs Unions (CU)	9600	Mario Larch's RTA Database
Number of Free Trade Agreements (FTA)	9600	Mario Larch's RTA Database
Number of Partial Scope Agreements (PSA)	9600	Mario Larch's RTA Database
Number of Economic Integration Agreements (EIA)	9600	Mario Larch's RTA Database
Regional Trade Agreements (RTA)(dummy)	9600	Mario Larch's RTA Database
Customs Unions (CU)(dummy)	9600	Mario Larch's RTA Database
Free Trade Agreements (FTA)(dummy)	9600	Mario Larch's RTA Database
Partial Scope Agreements (PSA)(dummy)	9600	Mario Larch's RTA Database
Economic Integration Agreements (dummy)	9600	Mario Larch's RTA Database